EP 155 April 1997

- Do your work in the space provided. You may write on the back of a sheet, but please indicate that you have done so.

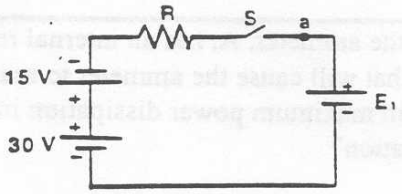
Marks

1. In the circuit shown below, the switch is closed at t = 0 and reopened at t = 10 seconds. During the time interval while the switch is closed, 1.0 C of positive charge passes point "a" in the direction from left to right. During this 10 second interval, the resistor converts 1.0 J of electrical energy to heat.

(5) (a) What is the value of the resistor R and the battery voltage E_1?

(5) (b) Energy is transferred among the circuit elements while the switch is closed. Did the 30 V battery provide or receive energy during the time interval 0 to 5 seconds, and how much energy did the battery provide or receive?

(5) (c) Is the 15 V battery providing or receiving energy at t = 7 seconds, and what is the rate of energy transfer at that instant?



Your Name_____

2. An engineer is designing a light bulb for use in a flashlight. The flashlight will be powered by two alkaline D cells (batteries) in series, each of which provides 1.5 V and has an internal resistance of 0.25 Ω. The engineer decides to use tungsten wire for the filament. The operational temperature of the filament is to be 2700° C.

(5) (a) If the filament resistance at operating temperature is to be 6 Ω, and the length of the filament is chosen to be 10 cm, what would the cross-sectional area of the filament have to be?

(5) (b) If instead of the 6-Ω design, it is decided to design the lamp to dissipate 1.0 W at operational temperature. What possible value or values of filament resistance at operational temperature would satisfy this design choice? If there is more than one resistance value, which is the best choice? Give your reasons why.

(5) (c) Is there an upper limit on the amount of power that the light bulb can be designed to draw from the batteries? If so, what is that limit, or if not, why not?

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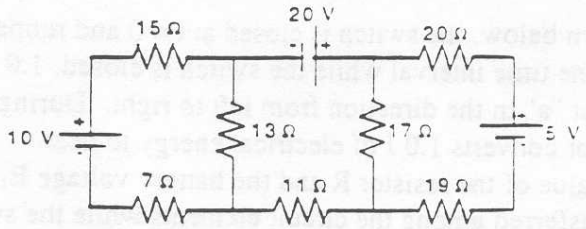
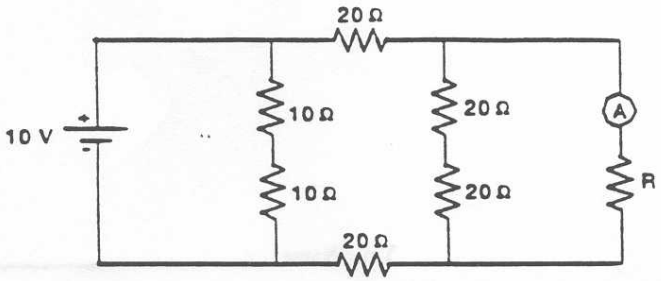
(15) 3. What is the current through the 5 V battery in the circuit shown below?



Your Name_____

(8) 4. (a) In the circuit shown below, the ammeter, A, has an internal resistance of 1.0 Ω. What is the value of R that will cause the ammeter to read 10 mA?

(7) (b) What value of R will result in maximum power dissipation in R? What is that maximum power dissipation?



Your Name_____

5. V_1 and V_2 are voltmeters, with possibly different internal resistances. If these meters are connected as shown in Figure 1 below,
- with S_1 closed and S_2 open, V_1 reads 5.0 V.
- with S_2 closed and S_1 open, V_2 reads 2.0 V.

If the two meters are connected as shown in Figure 2 below, V_1 reads 5.0 V.

(6) (a) What is the reading of V_2 in Figure 2?

(9) (b) What is the battery voltage E?

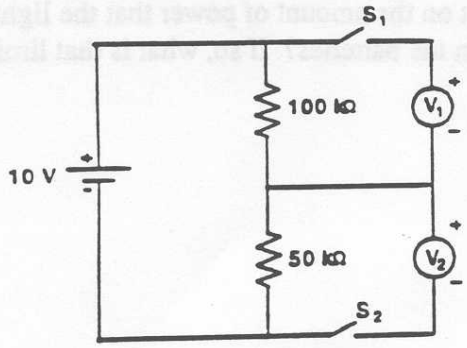


Figure 1

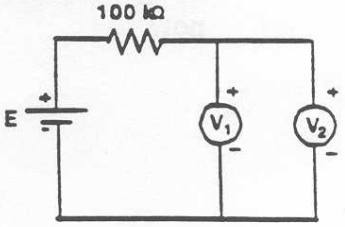


Figure 2

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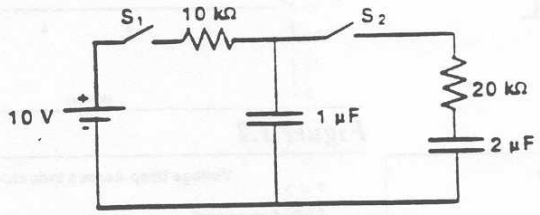
Your Name_____

6. For the circuit shown below, both capacitors are initially uncharged. Then S_1 is closed for 14 ms and re-opened. Finally, S_2 is closed and remains closed.

(6) (a) What is the voltage across the 1 μF capacitor during the time interval between re-opening S_1 and closing S_2?

(9) (b) What was the final value of the energy stored in the 2 μF capacitor?

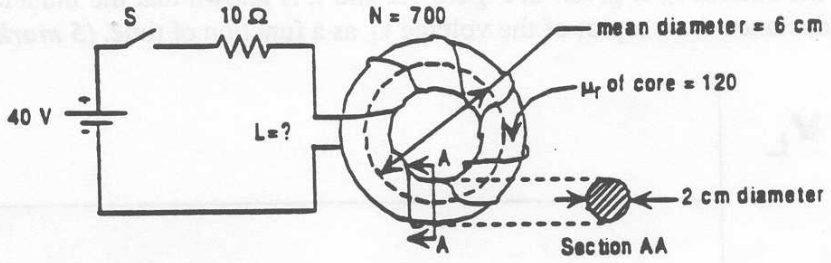


7. For the system shown below, the 10 Ω represents the resistance of the coil. The switch is initially open and then is closed at time t = 0.

(6) (a) What are the steady-state flux and flux density in the core after the switch has been closed a long time?

(4) (b) What is the inductance of the coil?

(5) (c) How long will it take for the flux to reach one-half of its steady state value after closing the switch, and what is the magnitude of the current at that instant?



8. The switch in the circuit shown below has been closed for a long time, and the 15 Ω resistor dissipates energy at a rate of 60 watts as long as the switch remains closed.

(5) (a) How much total energy will the battery deliver to the four elements during one minute of steady state operation with the switch closed?

(5) (b) If the switch is now opened, what are the new steady state conditions?

(5) (c) How much energy will each of the 5 Ω and 15 Ω resistors dissipate during the time interval between opening the switch and achieving final steady state conditions?